AMENDMENT TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims

1. (Currently Amended) A computer-based method for locating one or more landmarks using an MR image of a brain, the method including the following automatic steps:

(a) identifying a region of interest (ROI) with a plane of the MR image, the plane containing the landmark(s);

(b) binarising the plane of the MR image into foreground and background voxels based on at least one threshold selected using anatomical knowledge, the threshold being selected by maximizing a function which is a sum of variances of voxel intensities below and above the threshold;

(c) identifying a set of object voxels from the foreground voxels, the set of object voxels being formed by a sub-step of excluding from the foreground voxels a plurality of voxels which were only classified as foreground voxels due to proximity of cortical and non-cortical structures;

(d) identifying and restoring object voxels ~~from the background voxels~~ lost during the excluding sub-step of step (c) ~~due to partial volume effect and/or morphological erosion/opening~~, the restored object voxels being: object voxels located far from the skull, and lost due to the morphological opening operation(s); object voxels located around the boundaries of the object, and lost due to the morphological opening operation(s); and object voxels lost due to the partial volume effect; and

(e) identifying the one or more landmarks using the object ~~voxel~~ voxels identified in the steps (c) and (d).

2. (Original) A method according to claim 1 in which the step of identifying the object voxels is performed in two stages:

(i) morphological processing which excludes foreground voxels which may not be object voxels, and

(ii) restoring voxels which have been incorrectly excluded in the morphological processing.

3. (Original) A method according to claim 2 in which the step of identifying the object voxels further includes applying anatomical knowledge to identify the object voxels.

4. (Original) A method according to claim 3 in which the anatomical knowledge is knowledge about the expected shapes of cortical and/or non-cortical structures.

5. (Previously Presented) A method according to claim 1, wherein the threshold is selected by the steps of:

(i) using prior knowledge about the image to derive an intensity range of voxels in said region of interest;

(ii) obtaining a frequency distribution of intensities within said intensity range of voxels within said region of interest; and

(iii) using the frequency distribution to derive an intensity threshold.

6. (Cancelled)

7. (Currently Amended) A method according to claim [[6]] 1 in which said function is a weighted sum defined based on two constants W_1 and W_2.

8. (Previously Presented) A method according to claim 7, comprising labeling possible values of voxel intensity by an integer index *i* and their respective frequencies by *h(i)*, and writing the lower and upper intensities respectively as r_{low} and r_{high}, wherein the weighted sum is given by

$$\theta_{RCLWV}(W_1, W_2) = \max_{r_k} (\Pr(C_1)D(C_1)W_1 + \Pr(C_2)D(C_2)W_2),$$

where *Pr(.)* denotes class probability ($\Pr(C_1) = \sum_{i=r_{low}}^{r_k} h(i)$ and $\Pr(C_2) = \sum_{i=r_k+1}^{r_{high}} h(i)$), and

D(C1) and *D(C2)* are given by:

$$D(C_1) = (\mu_0 - \mu_T)^2, \text{ and } D(C_2) = (\mu_1 - \mu_T)^2,$$

where $\mu_T = \sum_{i=r_{low}}^{r_{high}} i \times h(i)$, $\mu_0 = \sum_{i=r_{low}}^{r_k} i \times h(i)$, and $\mu_1 = \sum_{i=r_k+1}^{r_{high}} i \times h(i)$.

9. (Previously presented) A method according to claim 1, wherein the steps (a) to (e) are performed repeatedly, in each set of steps identifying at least one corresponding landmark.

10. (Previously Presented) A method according to claim 1, wherein steps (a) to (d) are performed to locate A, P, L and R landmarks, and wherein

in step (a) the region of interest being defined within the AP plane; and

in step (e) the most anterior and most posterior of the object voxels being taken respectively as the vertical coordinates of the A and P landmarks respectively, and the extreme horizontal components of the object voxels are taken as the horizontal coordinates of the L and R landmarks respectively.

11. (Previously Presented) A method according to claim 10 wherein step (c) comprises:

performing at least one morphological opening operation on the binarized image obtained in step (b); and

classifying one or more voxels of the image(s) obtained by the opening operation(s) as object voxels or otherwise according to at least one criterion based on distances in the image(s) obtained by the opening operation(s) and anatomical knowledge.

12. (Previously Presented) A method according to claim 11 in which, prior to classifying the voxels, a maximum distance maxDSkull is obtained from a distance transform of the ROI.

13. (Cancelled)

14. (Previously Presented) A method according to claim 1 wherein steps (a) to (d) are performed to obtain an S landmark, the method comprising:

in step (a), defining the region of interest within a virtual plane obtained from a VPC coronal slice; and

in step (e), identifying the position of the S landmark as the most superior point of the object voxels.

15. (Previously Presented) A method according to claim 14 wherein step (c) comprises:

performing at least one morphological opening operation on the binarized image obtained in step (b); and

classifying as object voxels one or more voxels of the image(s) obtained by the morphological opening operation(s) if they belong to eight voxels immediately adjacent

to an object voxel and if their intensity value in the MR image is higher than a value defined in relation to a second threshold.

16. (Previously Presented) A method according to claim 1, wherein the set of steps (a) to (d) is performed to identify an I landmark, comprising:

in step (a), defining the region of interest within a VAC plane;

in step (e), defining the I landmark as the most inferior point of the object voxels.

17. (Previously Presented) A method according to claim 16 in which the threshold is obtained during a preceding process of locating an S landmark.

18. (Previously Presented) A method according to claim 16 in which, in step (c),

(i) at least one morphological opening operation, and/or

(ii) at least one seeding operation,

are performed on the binarized image obtained in step (b).

19. (Original) A method according to claim 18 in which, in step (c), one or more voxels of the image(s) obtained by the morphological opening operation(s) which are not presently classified as object voxels are re-classified as object voxels if they are one of the eight immediate neighbours of an object voxel and if their intensity value in the MR image is higher than a value defined in relation to a second threshold.

20. (Previously Presented) A method according to claim 16, wherein the left and right halves of the brain are treated separately, and the object voxels used to obtain the location of the I landmark relate to a selected half of the brain, the selected half of the brain having been selected based on a predefined criterion.

21. (Currently Amended) A system for locating one or more landmarks using an MR image of a brain, the system including:

an interface to receive data encoding the MR image; and

a processor arranged to perform the following steps:

(a) identifying a region of interest with a plane of the MR image, the plane containing the landmark(s);

(b) binarising the plane of the MR image into foreground and background voxels based on at least one threshold selected using anatomical knowledge, the threshold being selected by maximizing a function which is a sum of variances of voxel intensities below and above the threshold;

(c) identifying a set of object voxels from the foreground voxels, the set of object voxels being formed by a sub-step of excluding from the foreground voxels a plurality of voxels which were only classified as foreground voxels due to proximity of cortical and non-cortical structures;

(d) identifying and restoring object voxels ~~from the background voxels~~ lost during the excluding sub-step of step (c) ~~due to partial volume effect and/or morphological erosion/opening~~, the restored object voxels being: object voxels located far from the skull, and lost due to the morphological opening operation(s); object voxels located around the boundaries of the object, and lost due to the morphological opening operation(s); and object voxels lost due to the partial volume effect; and

(e) identifying the one or more landmarks using the object voxels identified in the steps (c) and (d).